

Brown so appropriately terms the "reduced constituent of chlorophyll." My persistent endeavours resulted in the discovery of *protophylline*, a substance obtainable through the action of nascent hydrogen on chlorophyll solutions.<sup>1</sup> Some years later I discovered this substance in the living plant.<sup>2</sup>

The existence of a *reduced constituent of chlorophyll* may be consequently considered as a perfectly established fact, and will be probably brought to account by the chemical theory of the chlorophyll function. I conclude my French paper with the following words:—"L'étude de ces substances ne manquera pas à jeter une vive lumière sur le côté chimique de la fonction chlorophyllienne qui a été étudié dans ce dernier temps presque exclusivement au point de vue physique."

To sum up: though it may be clearly seen that for nearly thirty years I have been considering chlorophyll as a *chemical sensitiser* (or, strictly speaking, an *absorbent* of the products of dissociation of  $\text{CO}_2$  and  $\text{H}_2\text{O}$ ), still even now I must confess that this theory lacks direct experimental proof and may be considered only as a matter for further research, whereas the physical aspect of the question (*i.e.* that  $\text{CO}_2$  and  $\text{H}_2\text{O}$  are decomposed through the agency of those rays of the spectrum, which are absorbed and somehow transformed by chlorophyll) is but the expression of a fact, put beyond any doubt by my researches, both on the decomposition of  $\text{CO}_2$  and on the production of starch in the living plant.<sup>3</sup> But I do not abandon the hope that the discovery of the *protophylline* may turn out some day to be a step in the direction of a *chemical theory* of the chlorophyll function, somewhat similar to that of the colouring matter of the blood—an analogy which has been present to my mind ever since I became acquainted with the classical researches of Sir G. G. Stokes in that direction.

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CLEMENT TIMIRIAZEFF.

I REGRET that M. Timiriazeff should regard the concluding lines of my presidential address as doing him some injustice.

No one can be more impressed than I have been with the extreme beauty and importance of M. Timiriazeff's work, which cleared away many illusions, and for the first time prominently brought out the fact that the rays corresponding to the principal absorption band of the chlorophyll spectrum are those which are mainly active in the assimilatory process.

I have always regarded M. Timiriazeff's paper of 1885 (*Ann. des Sciences Nat. [Bot.]*, vol. ii. p. 99) as being one of the most convincing and eloquent expositions in scientific literature, and the final proof of the proposition there laid down was given by the author in 1890 (*Compt. rend.* 110, 1346), when he succeeded in showing that the reappearance of starch in a depleted leaf exposed to a pure spectrum only takes place in the region of the red corresponding exactly to the principal absorption band of chlorophyll.

With regard to the first point raised in M. Timiriazeff's letter, I may say that when preparing my address I experienced a difficulty in ascertaining who it was that first drew attention to the existing analogy between chlorophyll and a chromatic sensitiser.

There is no complete list of Sir William Abney's papers, and knowing that he has sent many communications on this and cognate subjects to photographic journals in various parts of the world, I applied to Sir William Abney before writing what I did. There can be no doubt that chromatic sensitisers were very much "in the air" immediately after Vogel's discoveries of 1873, and it is probable that the application of these new ideas to chlorophyll occurred independently to Abney, Timiriazeff and Becquerel.

M. Timiriazeff's second objection is that I have not sufficiently taken into account his views of the function of chlorophyll as a *chemical sensitiser*. On this point I may say that I had in view his paper of 1885: "État actuel de nos connaissances sur la fonction chlorophyllienne," which it was fair to imagine fully embodied the author's view up to that date. It is certainly the *physical rôle* of chlorophyll which is there insisted upon, as the following quotation indicates: "Le rôle de la chlorophylle dans le phénomène de la décomposition de l'acide carbonique peut donc être résumé ainsi: elle absorbe les radiations qui possèdent

<sup>1</sup> The first description of this curious substance was given in two short notes communicated to these columns: "Colourless Chlorophyll" (*NATURE*, 1885, p. 342) and "Chlorophyll" (*NATURE*, 1886, p. 52). For more ample details, see *Comptes rendus*, 1889.

<sup>2</sup> "La protophylline dans la plante vivante" (*Comptes rendus*, 1889).

<sup>3</sup> "Enregistrement photographique de la fonction chlorophyllienne par la plante vivante" (*Comptes rendus*, 1884).

la plus grande énergie et transmet cette énergie aux molécules de l'acide carbonique qui, à elles seules, n'éprouveraient pas de décomposition, étant transparentes pour ces radiations énergiques."

That the physical conception was certainly uppermost in M. Timiriazeff's mind at that time is further shown by the diagram and remarks immediately following, in which he regards the molecules of carbon dioxide as suffering "shipwreck" in the luminous undulations corresponding to maximum amplitude.

It is, however, quite clear from M. Timiriazeff's references to his paper of 1877, and especially to his Russian paper of 1871, neither of which I have seen, that he has expressed views which are practically identical with those contained in the concluding remarks of my address. It is to be regretted that these ideas were not again clearly brought forward in the 1885 paper, which purported to give the author's latest views on the whole question, and that the physical idea of the immediate transference of the energy of radiation was there made the dominant one.

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### A Simple Experiment on Thermal Radiation.

THE following experiment, which has been successfully performed by our students for several years, may be of interest to teachers of physics.

Three chemical thermometers are chosen of equal size and shape. The bulb of one is silvered, of the other covered with dead black paint by dipping it into a mixture of lamp-black and alcohol, whilst the third is left unchanged. For silvering, any of the well-known solutions and processes will be applicable. The thermometers indicate the same temperature if there is no source of radiation near them.

But if a gas flame, for example, an Argand burner, be placed at a distance of 20 centimetres from them, so that the thermometers, hanging from a stand, are at equal distances from the flame, the temperature rises at a different rate, and to a different, though in each thermometer constant, height. The silvered

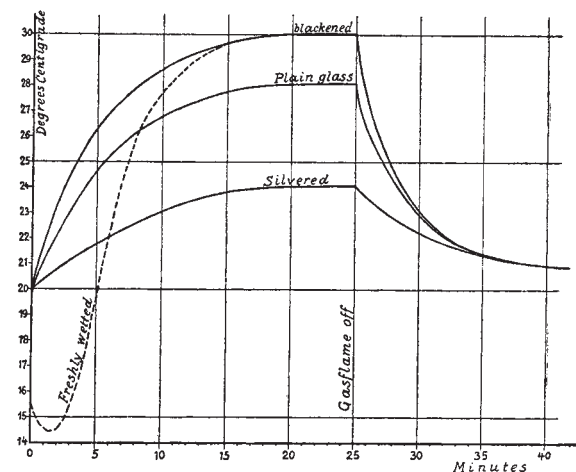


FIG. 1.

thermometer gives the lowest reading, and the blackened the highest, whilst the thread of the uncovered one stops at some point between these readings nearer to that of the blackened than the silvered; for the different surfaces of the thermometers absorb the radiation of heat generated in the flame in different proportion. The blackened thermometer bulb almost completely absorbs the rays falling on it; the silvered and polished bulb reflects the radiation reaching it; the plain glass bulb partly reflects and partly absorbs the rays. Thus, none but the silvered bulb thermometer indicates the temperature of the air communicating heat to it by conduction. As the other thermometers rise in temperature, they emit radiation; and when the amount of heat emitted from them equals the amount received through radiation from the gas flame, they are in the final stationary state, which is, of course, reached by the thermometers at different temperatures.

If the gas flame is put out, the temperatures of the three